

PATENT ABSTRACTS OF JAPAN

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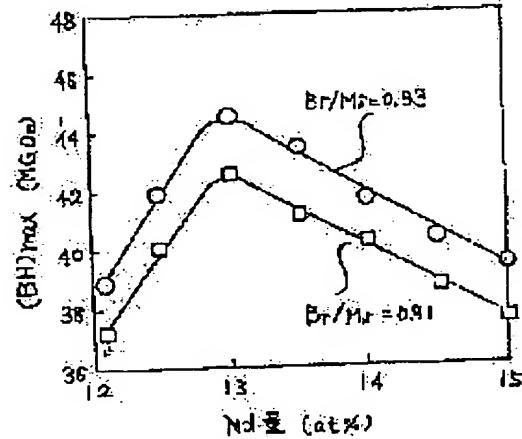
(71)Applicant : HITACHI METALS LTD
 (72)Inventor : ENDO MINORU

(54) RARE EARTH PERMANENT MAGNET

(57)Abstract:

PURPOSE: To clarify the combination of orientation required for raising the performance of an Nd-Fe-B magnet and main phase volume percentage, and clarify the optimum quantity of a phase rich in Nd and a phase rich in B, and clarify the structure form required to obtain target property.

CONSTITUTION: This magnet has the structure of $(Nd_{1-x-y}Ce_xPr_yDy_z)_aFe_bCocBdADeMfAlg$ (here, $0.01 \leq x \leq 0.1$, $0.05 \leq y \leq 0.5$, $0.001 \leq z \leq 0.25$, AD is at least one kind out of Cu, Zn, and Ga, and M is at least one kind out of V, Mo, Nb, and W, and $5 \leq a \leq 18$ at%, $65 \leq b \leq 85$ at%, $0 \leq c \leq 20$ at%, $4 \leq d \leq 15$ at%, $0 \leq e \leq 7$ at%, $0 \leq f \leq 7$ at%, and $0 \leq g \leq 5$ at%). This is a rare earth permanent magnet consisting of a sintered substance where the orientation degree (Br/Ms) is 0.90-0.97, the main phase volume percentage is 90-97%, and the volume percentage of other nonmagnetic phase is 3-10%.



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(71)出願人 000005083

日立金属株式会社

東京都千代田区丸の内2丁目1番2号

(72)発明者 遠藤 実

埼玉県熊谷市三ヶ尻5200番地日立金属株式

会社磁性材料研究所内

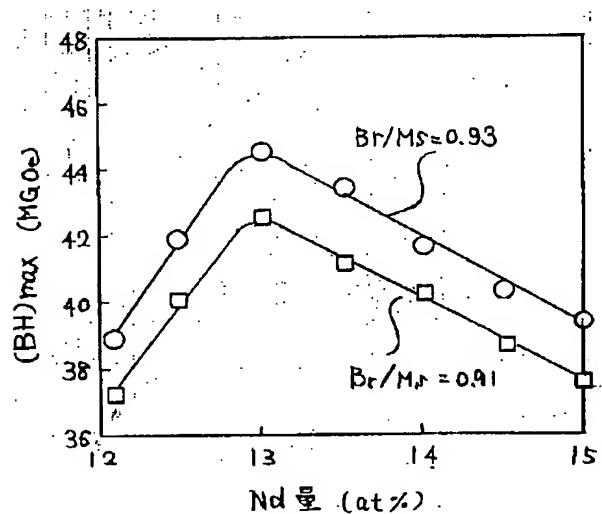
(74)代理人 弁理士 大場 充

(54)【発明の名称】 希土類永久磁石

(57)【要約】

【目的】 Nd-Fe-B系磁石を高性能化するのに必要な配向度と主相体積率の組み合わせを明らかにし、且つNdリッチ相とBリッチ相の最適量を明かにし、目標特性を得るのに必要な組織形態を明かにする。

【構成】 $(Nd_{1-x-y-z}Ce_xPr_yDyz)_aFe_bCo_cBdADeMfAl_g$ (ここで、 $0.001 \leq X \leq 0.1$ 、 $0.05 \leq Y \leq 0.5$ 、 $0.001 \leq Z \leq 0.2$ 、ADはCu, Zn, Gaのうち少なくとも1種で、MはV, Mo, Nb, Wのうち少なくとも1種で、 $5 \leq a \leq 18$ at%、 $6.5 \leq b \leq 8.5$ at%、 $0 \leq c \leq 20$ at%、 $4 \leq d \leq 15$ at%、 $0 \leq e \leq 7$ at%、 $0 \leq f \leq 7$ at%、 $0 \leq g \leq 5$ at%)の組成を有し、配向度(B_r/M_s)が $0.90 \sim 0.97$ で、主相体積率が90~97%、その他非磁性相の体積率が3~10%で、ある焼結体からなる希土類永久磁石。



【特許請求の範囲】

【請求項1】 R_2T_14B 化合物（Rは希土類金属元素、Tは遷移金属元素）を主体とする主相と非磁性相とから構成されるR-T-B系希土類永久磁石であり、配向度（ B_r/M_s ）が0.90～0.97で、主相体積率が89～97%、その他非磁性相の体積率が3～10%である焼結体からなることを特徴とする希土類永久磁石。

【請求項2】 主相体積率が89～95%、その他非磁性相の体積率が5～10%で、（BH）_{max}が38～46MGOeである請求項1に記載の希土類永久磁石。

【請求項3】 主相体積率が92～97%、その他非磁性相の体積率が3～7%で、（BH）_{max}が42～53MGOeである請求項1に記載の希土類永久磁石。

【請求項4】 Ndリッチ相の体積率が2～8%で、Bリッチ相の体積率が0.05～8%である請求項1～3のいずれかに記載の希土類永久磁石。

【発明の詳細な説明】

【0001】

【産業上の利用分野】 本発明は、VCM（ボイスコイルモータ）、回転機器等に使用される高性能希土類永久磁石に関するものである。

【0002】

【従来の技術】 Nd-Fe-B系磁石（特許公告 昭63-65742）は飽和磁化が大きく、高エネルギー積が得られることから幅広い用途に使用されるようになった。これまで問題とされていた耐熱性および耐食性といった問題はある程度解決され、実用上は問題ある程度解決された。最大エネルギー積も30～40MGOeのものが生産されるになった。

【0003】

【発明が解決しようとする課題】 近時永久磁石を用いた装置のより一層の小型化が要求されており、それにともないより高いエネルギー積を有する永久磁石の登場が望まれている。そこで本発明は、エネルギー積の高い希土類磁石の提供を課題とする。

【0004】

【課題を解決するための手段】 Nd-Fe-B系磁石を高性能化するには結晶粒の配向度を向上させ、且つ酸素量を低減することにより全希土類元素量を低減し、主相体積率を向上させることが不可欠となる。ここで配向度とは各々の結晶粒において磁化容易軸がどの程度揃っているかを表す数値で、通常残留磁束密度 B_r と飽和磁化 M_s の比（ B_r/M_s ）で表される。配向度を向上させるには、成形過程で磁界中配向した場合微粉碎粉が磁的に凝集するので、この磁気凝集を緩和し、配向を乱さないように成形する必要がある。また、主相体積率を向上させるにはNdリッチ相、Bリッチ相、酸化物相、Nb析出物、ポア等の非磁性相を最小限に抑えることが必要となる。しかし、主相体積率を多くしても、Ndリッ

チ相がないと良好な磁気特性が得られないし、Bリッチ相がなくなるとFeが生成し、角型性を悪くする。このため、Ndリッチ相とBリッチ相には良好な磁気特性を出すための範囲が存在する。

【0005】 本発明は以上の知見にもとづきなされたものであり、 R_2T_14B 化合物（Rは希土類金属元素、Tは遷移金属元素）を主体とする主相と非磁性相とから構成されるR-T-B系希土類永久磁石であり、配向度（ B_r/M_s ）が0.90～0.97で、主相体積率が89～97%、その他非磁性相の体積率が3～10%である焼結体からなることを特徴とする希土類永久磁石である。

【0006】 以下本発明をさらに詳述する。本発明希土類永久磁石は、配向度（ B_r/M_s ）が0.90～0.97で、主相体積率が89～97%、その他非磁性相の体積率が3～10%であるが、配向度（ B_r/M_s ）が0.90～0.94で、主相体積率が89～95%、その他非磁性相の体積率が5～10%の場合に（BH）_{max}=40～46MGOeの特性が、また配向度（ B_r/M_s ）が0.92～0.97で、主相体積率が92～97%で、その他非磁性相の体積率が3～7%の場合に（BH）_{max}=42～53MGOeの特性が得られる。

【0007】 主相以外の非磁性相は、Ndリッチ相の体積率が2～8%で、Bリッチ相の体積率が0.1～8%であることが好ましい。Ndリッチ相は体積率で2%未満では液相焼結ができずに、良好な特性が得られないで体積率で2%以上とする。望ましくは2.3%以上である。Bリッチ相が存在しない場合にはFeが生成し角型性が悪くなり、体積率で0.1%以上ならFeは生成せず優れた磁気特性が得られる。よって体積率で0.5%以上とする。しかし、Ndリッチ相、Bリッチ相はそれぞれ8%を超えて存在すると磁気特性を低下させるので好ましくない。

【0008】 本発明希土類永久磁石の組成としては下記のものが望ましい。

$(Nd_{1-x-y-z}Ce_xPr_yDyz)_{a}Fe_bCo_cB_dAD_eM_fA_1g$

（ここで、 $0.001 \leq X \leq 0.1$ 、 $0.05 \leq Y \leq 0.5$ 、 $0.001 \leq Z \leq 0.25$ 、ADはCu、Zn、Gaのうち少なくとも1種で、MはV、Mo、Nb、Wのうち少なくとも1種で、 $5 \leq a \leq 18$ at%、 $65 \leq b \leq 85$ at%、 $0 \leq c \leq 20$ at%、 $4 \leq d \leq 15$ at%、 $0 \leq e \leq 7$ at%、 $0 \leq f \leq 7$ at%、 $0 \leq g \leq 5$ at%）

希土類元素Rは5 at%以上、18 at%以下で、好ましくは10 at%以上、16 at%以下での範囲で含有される。Ceの過剰な添加は好ましくなく、 $0.001 \leq X \leq 0.1$ が望ましい。Prは $0.05 \leq Y \leq 0.5$ の範囲で使用すれば保磁力・耐熱性の向上に効果があるが、これ以上の添加は飽和磁化を減少させ、耐食性も低

下させる。Dyを含む場合に大きい保磁力が得られ、Nd+Ce+PrとDyの比率としては9.95:0.05から7.5:2.5の範囲が飽和磁化を大きく低下せずに、高保磁力が得られるため望ましい。

【0009】Feは6.5≤b≤8.5at%の範囲で含まれる。6.5at%未満では飽和磁化が低く、また8.5at%を越えると保磁力が著しく低下するからである。

【0010】Coは熱安定性向上に寄与する元素であり、2.0at%以下の範囲で含まれる。2.0at%を越えると飽和磁化と保磁力が低下するからである。なお、FeとCoの比率は、適度な角型性と保磁力を保持するため9.95:0.05から7.7:2.3の範囲にするのが望ましい。

【0011】Bの量は4≤d≤1.5at%が好ましく、この範囲外では残留磁束密度と保磁力が小さくなる。

【0012】ADは保磁力を向上させるための元素であるが、7at%を越えると残留磁束密度を低下させるので7at%以下とする。0.01≤e≤4at%の範囲とするのが好ましい。

【0013】M元素は結晶粒成長抑制および熱安定性向上に効果のある元素であるが、過剰に含まれると飽和磁化を低下させるので添加する場合は7at%以下するのが好ましい。

【0014】Alは保磁力向上に効果があり、Ferro-Bからおよび溶解時に混入してくる。しかし過剰に含まれるとキュリー温度を下げる所以、添加する場合は5at%以下とする。

【0015】次に本発明磁石の製造方法について説明する。本発明磁石は、焼結法により作製することができる。溶解インゴットを作製しこのインゴットに水素吸蔵・脱水素処理を施した後、微粉碎し、その後に磁場中成形、焼結、熱処理することにより得られる。

【0016】

【実施例】

(実施例1) 金属Nd、金属Dy、Fe、Co、ferro-B、ferro-Nbを下記組成になるように秤量し、これを真空溶解して重量10kgのインゴットを作製した。Nd_xDy_{0.4}Fe_{88.1-x}Co_{4.5}B₆Nb_{0.5}Al_{0.5}(X=1.2.1~1.5.0)このインゴットをハンマーで解碎した後、さらに粗粉碎機を用い不活性ガス雰囲気中の粗粉碎を行い500μm以下の粒度の粗粉を得た。この粗粉を同じくジェットミルを用い不活性ガス雰囲気中で微粉碎をして微粉を得た。この微粉は平均

粒径4.0μm(F.S.S.S.)であった。次に、この微粉を磁場中プレス成形し、20×20×15の成形体を作製した。この成形体を焼結し、さらに熱処理を施すことによって永久磁石を得た。図1にNd量による(BH)_{max}の変化を示すが、Nd量が12.7at%以下の場合Ndリッチ相の減少により良好な特性が得られない。また、図1から明かのように、配向度(Br/Ms)が0.91の場合には(BH)_{max}=4.5MGOeを得られていないが、配向度が0.93の場合には(BH)_{max}=4.5MGOeが得られるているのがわかる。図2にNd_{12.8}Dy_{0.4}Fe_{75.3}Co_{4.5}B_{6.0}Nb_{0.5}Al_{0.5}の組成における酸素量とBリッチ相、Ndリッチ相、酸化物相、Nb析出物の体積率の変化を示す。酸素量の増加とともに酸化物相は増加するが、Ndリッチ相は減少する。Nb析出物およびBリッチ相は酸素量に拘らずほぼ一定である。なお酸素量が0.3wt%の時の主相体積率は9.4.28%であった。

【0017】(実施例2) 実施例1と同様にして組成Nd_{12.4}Dy_{0.4}Fe_{75.9}Co_{4.5}B_{5.9}Nb_{0.4}Al_{0.5}で、酸素量0.1wt%、ポア0.5vol%の磁石を得た。この磁石の配向度による(BH)_{max}の変化を図3に示す。この組成において配向度を0.958以上とすれば(BH)_{max}=5.0MGOeの特性が得られることがわかる。この時の主相体積は9.5.96%、Bリッチ相は0.1%、Ndリッチ相は2.62%、酸化物相は0.65%、Nb析出物は0.17%であった。

【0018】

【発明の効果】R-T-B系磁石において配向度と主相体積率、さらにNdリッチ相、Bリッチ相の最適化を図ることにより高性能磁石を得ることができた。

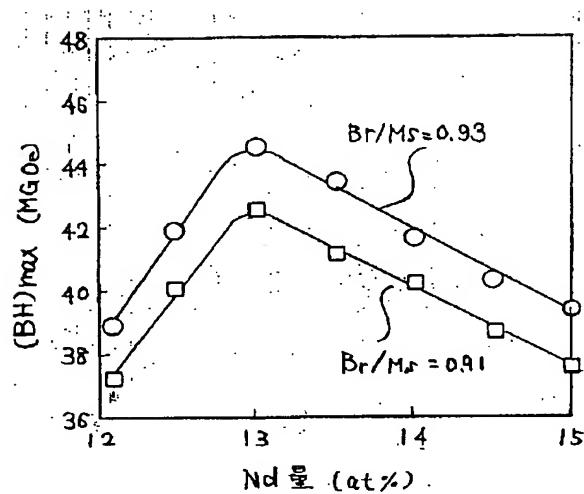
【図面の簡単な説明】

【図1】Nd_xDy_{0.4}Fe_{88.1-x}Co_{4.5}B₆Nb_{0.5}Al_{0.5}(x=1.2.1~1.5.0)の磁石においてNd量による(BH)_{max}の変化を示すグラフである。

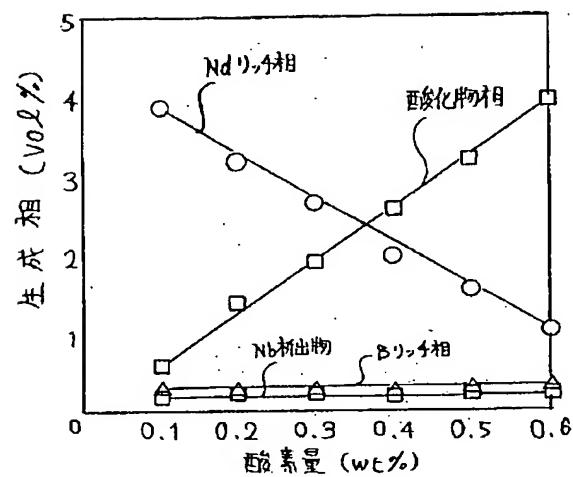
【図2】Nd_{12.8}Dy_{0.4}Fe_{75.3}Co_{4.5}B_{6.0}Nb_{0.5}Al_{0.5}の組成で酸素量を変化させた時のBリッチ相、Ndリッチ相、酸化物相、Nb析出物の体積率の関係を示すグラフである。

【図3】Nd_{12.4}Dy_{0.4}Fe_{75.9}Co_{4.5}B_{5.9}Nb_{0.4}Al_{0.5}で、酸素量0.1wt%、ポア0.5vol%の場合における、配向度による(BH)_{max}の変化を示すグラフである。

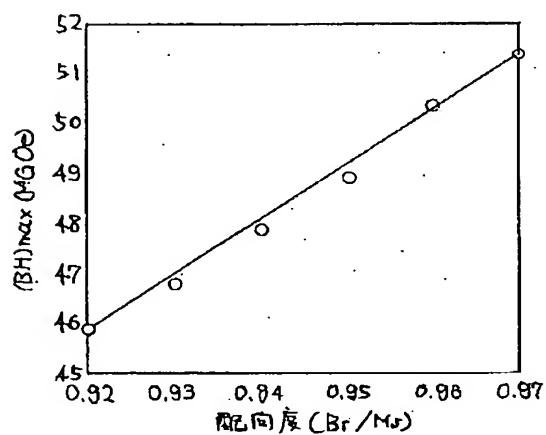
【図1】



【図2】



【図3】



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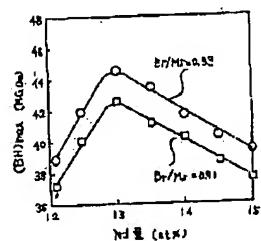
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yzCexPryDyz)aFebCocBdADeMfAlg (here, $0.01 \leq X \leq 0.1$, $0.05 \leq Y \leq 0.5$, $0.001 \leq Z \leq 0.25$, AD is at least one kind out of Cu, Zn, and Ga, and M is at least one kind out of V, Mo, Nb, and W, and $5 \leq a \leq 18$ at%, $65 \leq b \leq 85$ at%, $0 \leq c \leq 20$ at%, $4 \leq d \leq 15$ at%, $0 \leq e \leq 7$ at%, $0 \leq f \leq 7$ at%, and $0 \leq g \leq 5$ at%). This is a rare earth permanent magnet consisting of a sintered substance where the orientation degree (Br/Ms) is 0.90-0.97, the main phase volume percentage is 90-97%, and the volume percentage of other nonmagnetic phase is 3-10%.

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CLAIMS

[Claim(s)]

[Claim 1] The rare earth permanent magnet with which it is the R-T-B system rare earth permanent magnet which consists of a main phase which makes a subject an R2T14B compound (R is a rare earth metal element and T is a transition-metals element), and a nonmagnetic phase, the amounts of preferred orientation (Br/Ms) are 0.90-0.97, and the rate of the main phase volume is characterized by the rate of the volume of 89 - 97% and other nonmagnetic phases consisting of a sintered compact which is 3 - 10%.

[Claim 2] The rare earth permanent magnet according to claim 1 whose (BH) max the rate of the volume of 89 - 95% and other nonmagnetic phases is 38 - 46MGOe at 5 - 10% for the rate of the main phase volume.

[Claim 3] The rare earth permanent magnet according to claim 1 whose (BH) max the rate of the volume of 92 - 97% and other nonmagnetic phases is 42 - 53MGOe at 3 - 7% for the rate of the main phase volume.

[Claim 4] The rare earth permanent magnet according to claim 1 to 3 whose rate of the volume of B rich phase the rate of the volume of Nd rich phase is 0.05 - 8% at 2 - 8%.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the high performance rare earth permanent magnet used for VCM (voice coil motor), a rotating equipment, etc.

[0002]

[Description of the Prior Art] A Nd-Fe-B system magnet (patent public notice Showa 63-65742) has large saturation magnetization, and came to be used for the broad application from a high energy product being obtained. the problem of the thermal resistance and corrosion resistance which were made into the problem until now is solved to some extent, and is problematic practically -- extent solution was carried out. Also in the maximum energy product, the thing of 30 - 40MGOe was produced.

[0003]

[Problem(s) to be Solved by the Invention] Much more miniaturization of the equipment using a permanent magnet is demanded recently, and an appearance of a permanent magnet which has a higher energy product in connection with it is desired. Then, this invention offers a technical problem a rare earth magnet with a high energy product.

[0004]

[Means for Solving the Problem] By raising the amount of preferred orientation of crystal grain high-performance-izing a Nd-Fe-B system magnet, and reducing the

amount of oxygen, the total amount of rare earth elements is reduced, and it becomes indispensable to raise the rate of the main phase volume. The amount of preferred orientation is a numeric value showing with all of how much together an easy axis is in each crystal grain here, and it is usually expressed with the ratio (Br/Ms) of a residual magnetic flux density Br and saturation magnetization Ms. It is necessary to ease this magnetic condensation, and since pulverizing powder condenses magnetically when orientation in a field is carried out by the forming process in order to raise the amount of preferred orientation, it is necessary to fabricate so that orientation may not be disturbed. Moreover, it is necessary to hold down nonmagnetic phases, such as Nd rich phase, B rich phase, an oxide phase, Nb sludge, and pore, to raising the rate of the main phase volume to the minimum. However, even if it makes [many] the rate of the main phase volume, if there is no Nd rich phase, good magnetic properties will not be acquired, if B rich phase is lost, Fe will generate and square shape nature will be worsened. For this reason, the range for taking out good magnetic properties exists in Nd rich phase and B rich phase.

[0005] this invention is made based on the above knowledge -- having -- an R2T14B compound (R -- a rare earth metal element --) T is a R-T-B system rare earth permanent magnet which consists of a main phase which makes a transition-metals element a subject, and a nonmagnetic phase, and the amounts of preferred orientation (Br/Ms) are 0.90-0.97. The rate of the main phase volume is the rare earth permanent magnet characterized by consisting of a sintered compact whose rate of the volume of 89 - 97% and other nonmagnetic phases is 3 - 10%.

[0006] This invention is explained further in full detail below. The amounts of preferred orientation (Br/Ms) are 0.90-0.97, and although the rate of the volume of 89 - 97% and other nonmagnetic phases is 3 - 10%, the rate of the main phase volume this invention rare earth permanent magnet The rate of the main phase volume by 0.90-0.94 89 - 95%, [the amount of preferred orientation (Br/Ms)] When the rate of the volume of a nonmagnetic phase is 5 - 10%, the

amount of preferred orientation (Br/Ms) again in addition, by 0.92-0.97 [the property of (BH) max=40 - 46MGOe] The rate of the main phase volume is 92 - 97%, in addition when the rate of the volume of a nonmagnetic phase is 3 - 7%, the property of (BH) max=42 - 53MGOe is acquired.

[0007] The rate of the volume of Nd rich phase is 2 - 8%, and, as for nonmagnetic phases other than the main phase, it is desirable that the rate of the volume of B rich phase is 0.1 - 8%. Since a good property is not acquired at the rate of the volume, without making liquid phase sintering at less than 2%, Nd rich phase is made into 2% or more at the rate of the volume. It is 2.3% or more desirably. When B rich phase does not exist, Fe generates, square shape nature worsens, and if it is 0.1% or more at the rate of the volume, the magnetic properties which Fe did not generate but were excellent are acquired. Therefore, it may be 0.5% or more at the rate of the volume. However, since Nd rich phase and B rich phase will reduce magnetic properties if they exist exceeding 8%, respectively, they are not desirable.

[0008] As a presentation of this invention rare earth permanent magnet, the following are desirable.

(Nd_{1-X}-Y-ZCeXPrYDyZ) aFe_bC_cO_dB_eAl_fM_g (here) 0.001<=X<=0.1, 0.05<=Y<=0.5, 0.001<=Z<=0.25, and AD are at least one sort in Cu, Zn, and Ga, and M is at least one sort in V, Mo, Nb, and W. Five <=a<=18at% and 65 <=b<=85 at% and 0 <=c<=20 at%, 4 <=d<=15at% and 0 <=e<=7at% and 0 <=f<=7at% and 0 <=g<=5at%

Rare earth elements R are more than 5at% and less than [18at%], and are preferably contained in more than 10at% and not more than 16at%. As for superfluous addition of Ce, 0.001<=X<=0.1 is desirable preferably. Although Pr has effectiveness in coercive force and heat-resistant improvement if it is used in 0.05<=Y<=0.5, the addition beyond this decreases saturation magnetization and also reduces corrosion resistance. Since large coercive force is acquired and high coercive force is acquired, without the range of 99.95:0.05 to 75:25 falling saturation magnetization greatly as a ratio of Nd+Ce+Pr and Dy when Dy is

included, it is desirable.

[0009] Fe is contained in $65 \leq b \leq 85$ at%. It is because coercive force will decline remarkably less than [65at%] if saturation magnetization is low and exceeds 85at(s)%.

[0010] Co is an element contributed to the improvement in thermal stability, and is contained in not more than 20at%. It is because saturation magnetization and coercive force will decline if 20at(s)% is exceeded. In addition, as for the ratio of Fe and Co, it is desirable to make it the range of 99.95:0.05 to 77:23 in order to hold moderate square shape nature and coercive force.

[0011] the amount of B -- $4 \leq d \leq 15$ at% -- desirable -- this -- if out of range, a residual magnetic flux density and coercive force become small.

[0012] Although AD is an element for raising coercive force, since a residual magnetic flux density will be reduced if 7at% is exceeded, it may be less than [7at%]. It is desirable to consider as the range of $0.01 \leq e \leq 4$ at%.

[0013] Although M element is an element which has effectiveness in grain growth control and the improvement in thermal stability, since saturation magnetization will be reduced if contained superfluously, when adding, considering as less than [7at%] is desirable.

[0014] aluminum has effectiveness in the improvement in coercive force, and is mixed from Ferro-B at the time of the dissolution. However, since Curie temperature will be lowered if contained superfluously, when adding, it may be less than [5at%].

[0015] Next, the manufacture approach of this invention magnet is explained. this invention magnet is producible with a sintering process. After producing a dissolution ingot and performing hydrogen absorption and dehydrogenation treatment to this ingot, it pulverizes and is obtained by fabricating, sintering and heat-treating among a magnetic field after that.

[0016]

[Example]

(Example 1) Weighing capacity of Metal Nd, Metals Dy, Fe, and Co, ferro-B, and

ferro-Nb was carried out so that it might become the following presentation, vacuum melting of this was carried out, and the ingot with a weight of 10kg was produced. $NdxDy0.4Fe88.1-xCo4.5 B6Nb0.5aluminum0.5$ ($X=12.1-15.0$) -- after cracking this ingot with a hammer, coarse grinding in the inside of an inert gas ambient atmosphere was further performed using the coarse crusher, and coarse powder with a grain size of 500 micrometers or less was obtained. Similarly this coarse powder was pulverized in the inert gas ambient atmosphere using the jet mill, and fines were obtained. These fines were 4.0 micrometers (F. S.S.S.) in mean particle diameter. Next, press forming in a magnetic field of these fines was carried out, and the Plastic solid of $20x20x15$ was produced. This Plastic solid was sintered and the permanent magnet was obtained by heat-treating further. Although the change of $(BH)_{max}$ by the amount of Nd(s) is shown in drawing 1, a good property is not acquired by reduction of Nd rich phase when the amount of Nd(s) is less than [12.7at%]. Moreover, like [it is ***** from drawing 1 and], when the amount of preferred orientation (Br/Ms) is 0.91, $(BH)_{max}=45MGOe$ has not been obtained, but when the amount of preferred orientation is 0.93, that of ***** from which $(BH)_{max}=45MGOe$ is obtained is known. Change of the amount of oxygen in the presentation of $Nd12.8Dy0.4Fe75.3Co4.5B6.0Nb0.5aluminum0.5$, B rich phase, Nd rich phase, an oxide phase, and the rate of the volume of Nb sludge is shown in drawing 2. Although an oxide phase increases with the increment in the amount of oxygen, Nd rich phase decreases. Nb sludge and B rich phase are almost fixed irrespective of the amount of oxygen. In addition, the rate of the main phase volume in case the amount of oxygen is 0.3wt(s)% was 94.28%.

[0017] (Example 2) With presentation

$Nd12.4Dy0.4Fe75.9Co4.5B5.9Nb0.4aluminum0.5$, the pore 0.5vol% magnet was obtained amount of oxygen 0.1wt% like the example 1. The change of $(BH)_{max}$ by the amount of preferred orientation of this magnet is shown in drawing 3. In this presentation, it turns out that the property of 0.958 or more [then] and $(BH)_{max}=50MGOe$ is acquired in the amount of preferred orientation. For B rich

phase, Nd rich phase was [the main phase volume at this time / Nb sludge of the oxide phase] 0.17% 0.65% 2.62% 0.1% 95.96%.

[0018]

[Effect of the Invention] In the R-T-B system magnet, the aperiodic compass was able to be obtained the amount of preferred orientation, the rate of the main phase volume, and by attaining optimization of Nd rich phase and B rich phase further.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the graph which shows the change of (BH) max by the amount of Nd(s) in the magnet of $NdxDy0.4Fe88.1-xCo4.5B6Nb0.5aluminum0.5$ ($x=12.1-15.0$).

[Drawing 2] It is the graph which shows the relation of B rich phase when changing the amount of oxygen by the presentation of $Nd12.8Dy0.4Fe75.3Co4.5B6.0Nb0.5aluminum0.5$, Nd rich phase, an oxide phase, and the rate of the volume of Nb sludge.

[Drawing 3] At $Nd12.4Dy0.4Fe75.9Co4.5B5.9Nb0.4aluminum0.5$, it is the amount

0.1 of oxygen. It is the graph which shows the change of (BH) max by the amount of preferred orientation of pore 0.5vol% of case wt%.

[Translation done.]

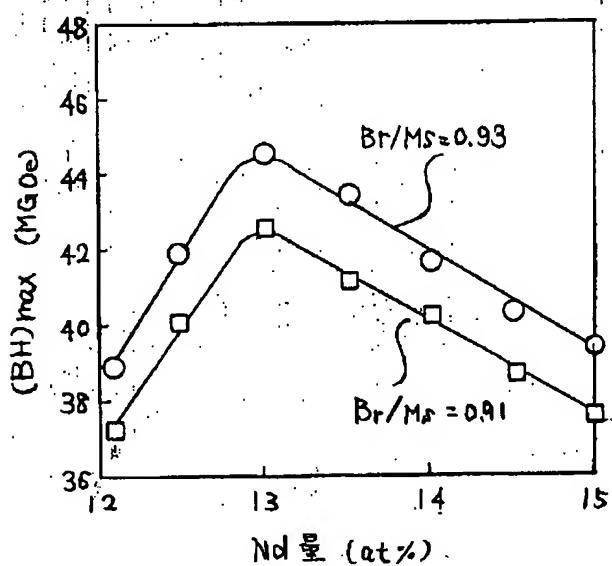
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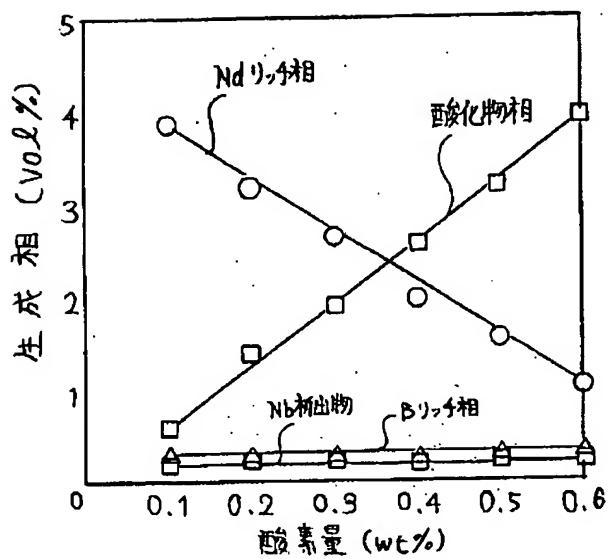
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DRAWINGS

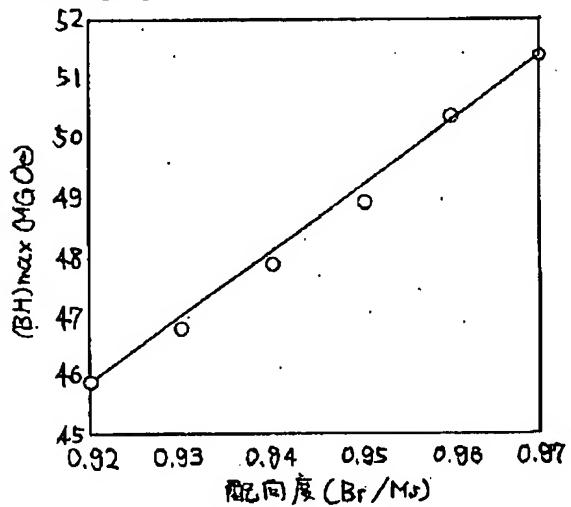
[Drawing 1]



[Drawing 2]



[Drawing 3]



[Translation done.]